

REMARKS

I. Introduction

In response to the Office Action dated July 2, 2007, claim 1 has been amended. Claims 2-17, and 19 remain in the application. Re-examination and re-consideration of the application, as amended, is requested.

II. Information Disclosure Statement

In paragraphs (1)-(2) of the Office Action, the office action notes that it is desirable to avoid the submission of long lists of documents in an information disclosure statement.

Applicants' attorney acknowledges the examiner's acknowledgement of the submitted information disclosure statement.

III. Prior Art Rejections

A. The Office Action Rejections

In paragraphs (3)-(4) of the Office Action, claims 1-5, 7, 8, 10, 16, 17, and 19 were rejected under 35 U.S.C. §102(e) as being anticipated by Motoki et al., U.S. Patent No. 6,468,882 (Motoki). In paragraphs (16)-(17) of the Office Action, claims 6 and 9 were rejected under 35 U.S.C. §103(a) as being unpatentable over Motoki in view of Kryliouk et al., U.S. Patent No. 6,218,280 (Kryliouk). In paragraph (20) of the Office Action, claims 11 and 12 were rejected under 35 U.S.C. §103(a) as being unpatentable over Motoki in view of Bliss et al., U.S. Patent No. 6,969,426 (Bliss). In paragraph (23) of the Office Action, claims 13, 14, and 15 were rejected under 35 U.S.C. §103(a) as being unpatentable over Motoki in view of Molnar, U.S. Patent No. 6,086,673 (Molnar).

Applicants' attorney respectfully traverses these rejections.

B. Applicants' Independent Claim

Applicants' amended independent claim 1 is directed to a method for forming a planar, non-polar gallium nitride (GaN) film on a substrate, comprising (a) loading a substrate into a reactor, (b) heating the reactor to a growth temperature, (c) reducing the reactor's pressure to a desired deposition pressure, wherein the desired deposition pressure is below atmospheric pressure, (d) initiating a gaseous hydrogen chloride (HCl) flow to a gallium (Ga) source to begin

heteroepitaxial growth of the non-polar GaN film directly on the substrate, wherein the gaseous HCl reacts with the Ga to form gallium monochloride (GaCl), transporting the GaCl to the substrate using a carrier gas that includes at least a fraction of hydrogen (H₂), wherein the GaCl reacts with ammonia (NH₃) at the substrate to form the GaN film, and (f) after a desired growth time has elapsed, interrupting the gaseous HCl flow, returning the reactor's pressure to atmospheric pressure, and reducing the reactor's temperature to room temperature, wherein the resulting non-polar GaN film has a planar and specular top surface suitable for subsequent device regrowth.

C. The Motoki Reference

Motoki describes GaN single crystal substrates that are produced by slicing a GaN single crystal ingot in the planes parallel to the growing direction. Penetration dislocations which have been generated in the growing direction extend mainly in the bulk of the GaN substrate. A few of the threading dislocations appear on the surface of the GaN substrate. GaN substrates of low-dislocation density are obtained.

D. The Kryliouk Reference

Kryliouk describes an invention that pertains to a method and device for producing large area single crystalline III-V nitride compound semiconductor substrates with a composition $\text{Al}_{1-x}\text{In}_x\text{Ga}_{1-x-y}\text{N}$ (where $0 \leq x \leq 1$, $0 \leq y \leq 1$, and $0 \leq x+y \leq 1$). In a specific embodiment, GaN substrates, with low dislocation densities (about 10^7 cm^{-2}) can be produced. These crystalline III-V substrates can be used to fabricate lasers and transistors. Large area free standing single crystals of III-V compounds, for example GaN, can be produced in accordance with the subject invention. By utilizing the rapid growth rates afforded by hydride vapor phase epitaxy (HVPE) and growing on lattice matching orthorhombic structure oxide substrates, good quality III-V crystals can be grown. Examples of oxide substrates include LiGaO_2 , LiAlO_2 , MgAlScO_4 , Al_2MgO_4 , and LiNdO_2 . The subject invention relates to a method and apparatus, for the deposition of III-V compounds, which can alternate between MOVPE and HVPE, combining the advantages of both. In particular, the subject hybrid reactor can go back and forth between MOVPE and HVPE

in situ so that the substrate does not have to be transported between reactor apparatus and, therefore, cooled between the performance of different growth techniques.

E. The Bliss Reference

Bliss describes a method and apparatus for forming metal nitride (MN), wherein M is contacted with iodine vapor or hydrogen iodide (HI) vapor to form metal iodide (MI) and then contacting MI with ammonia to form the MN in a process of reduced or no toxicity. Such method is conducted in a reactor that is maintained at a pressure below one atmosphere for enhanced uniformity of gas flow and of MN product. The MN is then deposited on a substrate, on one or more seeds or it can self-nucleate on the walls of a growth chamber, to form high purity and uniform metal nitride material. The inventive MN material finds use in semiconductor materials, in nitride electronic devices, various color emitters, high power microwave sources and numerous other electronic applications.

F. The Molnar Reference

Molnar merely describes a method for producing a nitride layer on a growth substrate. First a pretreatment layer is formed on the growth substrate, and then the formed pretreatment layer is exposed to a gaseous environment that is thermochemically reactive with the pretreatment layer. After gaseous environment exposure of the pretreatment layer, there is carried out an epitaxial growing process to produce on the substrate a nitride layer material defined as $\text{In}_{\text{sub}.x}\text{Ga}_{\text{sub}.y}\text{Al}_{\text{sub}.1-x-y}\text{N}$, where $0 \leq x \leq 1$; $0 \leq y \leq 1$; and $0 \leq x+y \leq 1$. For example, a pretreatment layer of ZnO can be deposited on a sapphire growth substrate and then subjected to a gaseous environment, e.g., including HCl- and/or NH_3 -containing gas, that is thermochemically reactive with the ZnO. Then an epitaxial layer of GaN can be grown by a hydride vapor phase epitaxial process on the pretreated substrate. The growth substrate can include a plane of mechanical weakness that is parallel with a predominant nitride growth surface of the substrate, and that is either inherently exhibited by the substrate or that is produced by processing of the substrate. Similarly, an interlayer of material characterized by a plane of mechanical weakness parallel with the predominant nitride growth surface can be formed on the substrate, preferably after the pretreatment layer deposition and gaseous environment exposure steps.

G. The Applicants' Invention is Patentable Over the References

Applicants' attorney respectfully submits that the claims are patentable over the references. Specifically, Applicants' claims recite limitations not shown in the references, taken individually or in combination.

As noted above, Applicants' amended claim 1 recites a method for forming a planar, non-polar gallium nitride (GaN) film on a substrate, comprising (a) loading a substrate into a reactor, (b) heating the reactor to a growth temperature, (c) reducing the reactor's pressure to a desired deposition pressure, wherein the desired deposition pressure is below atmospheric pressure, (d) initiating a gaseous hydrogen chloride (HCl) flow to a gallium (Ga) source to begin heteroepitaxial growth of the non polar GaN film directly on the substrate, wherein the gaseous HCl reacts with the Ga to form gallium monochloride (GaCl), transporting the GaCl to the substrate using a carrier gas that includes at least a fraction of hydrogen (H₂), wherein the GaCl reacts with ammonia (NH₃) at the substrate to form the GaN film, and (f) after a desired growth time has elapsed, interrupting the gaseous HCl flow, returning the reactor's pressure to atmospheric pressure, and reducing the reactor's temperature to room temperature, wherein the resulting non-polar GaN film has a planar and specular top surface suitable for subsequent device regrowth.

The Office Action, on the other hand, asserts the following:

Regarding claim 1, Motoki et al. disclose a method for forming a planar, nonpolar, a-plane gallium nitride (GaN) film on a substrate, comprising: (a) loading a substrate (fig. 1, 5) into a reactor (fig. 1, 5), (b) heating the reactor to a growth temperature (column 31 line 60 to column 32 line 16); (c) reducing the reactor's pressure to a desired deposition pressure (column 31 line 60 to column 32 line 16), wherein the desired deposition pressure is below atmospheric pressure; (d) initiating a gaseous hydrogen chloride (HCl) flow (in fig. 1, 7) to a gallium (Ga) source (fig. 1, 3) to begin growth of the a-plane GaN film directly on the substrate, wherein the gaseous HCL reacts with the Ga to form gallium monochloride (GaCl) (column 3 line 54 to column 4 line 6); (e) transporting the GaCl to the substrate using a carrier gas that includes at least a fraction of hydrogen (H₂), wherein the GaCl reacts with ammonia (NH₃) at the substrate to form the GaN film (column 3 line 54 to column 4 line 6); and (f) after a desired growth time has elapsed (column 31 line 60 to column 32 line 16), interrupting the gaseous HCl flow, returning the reactor's pressure to atmospheric pressure, and reducing the reactor's temperature to room temperature.

Applicants' attorney respectfully disagrees.

Motoki does not describe heteroepitaxially growing non-polar GaN directly on a substrate, as required by Applicants' amended independent claim 1. Heteroepitaxially is defined in Applicants' specification (page 4, lines 5-6) as growth on a foreign substrate that provides a reasonable lattice match to GaN. An example of heteroepitaxially growing non-polar GaN directly on a substrate includes growing a non polar GaN film directly on a sapphire substrate (see Applicants' specification page 7, lines 29-30).

Motoki, on the other hand, discloses homoeptaxially growing non-polar GaN directly on a non-polar GaN substrate. This is evidenced by Motoki's method, which involves (1) obtaining a non polar-plane GaN seed by slicing a polar (c-plane) GaN substrate along a non polar plane (see Motoki, col. 27, lines 46-56) and (2) growing non polar GaN on the non polar-plane GaN seed crystal (see Motoki, col. 30, lines 38-54, col. 31, lines 32-40, col. 31 lines 60-67). Motoki's non-polar GaN is not heteroepitaxially grown directly on a substrate because Motoki's non-polar GaN growth is directly on a non-polar GaN substrate.

While Motoki does disclose a foreign substrate (e.g. GaAs, see Motoki col. 27, lines 58-62), Motoki's non polar GaN growth is not directly on this foreign substrate because there are intermediate polar GaN growths and slicing steps before the non-polar GaN growth.

The remaining Kryliouk, Bliss, and Molnar references fail to overcome the deficiencies of Motoki. Recall that these references were only cited against the dependent claims, and were only relied upon for teaching the step of evacuating a reactor and backfilling a reactor with nitrogen, using nitrogen in a step of heating the substrate (Kryliouk), optimizing deposition pressure (Bliss), disclosing growth rates, including anhydrous ammonia in a gas stream during a reduction of a reactor's temperature, and operating a HVPE reactor at sub-atmospheric pressure (Molnar).

Thus, Applicants' attorney submits that independent claim 1 is allowable over Motoki, Kryliouk, Bliss, and Molnar. Further, dependent claims 2-17 and 19 are submitted to be allowable over Motoki, Kryliouk, Bliss, and Molnar in the same manner, because they are dependent on independent claim 1, respectively, and thus contain all the limitations of the independent claims. In addition, dependent claims 2-17 and 19 recite additional novel elements not shown by Motoki, Kryliouk, Bliss, and Molnar.

IV. Conclusion

In view of the above, it is submitted that this application is now in good order for allowance and such allowance is respectfully solicited. Should the Examiner believe minor matters still remain that can be resolved in a telephone interview, the Examiner is urged to call Applicants' undersigned attorney.

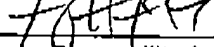
Respectfully submitted,

GATES & COOPER LLP
Attorneys for Applicants

Howard Hughes Center
6701 Center Drive West, Suite 1050
Los Angeles, California 90045
(310) 641-8797

Date: January 2, 2008

GHG/

By: 
Name: George H. Gates
Reg. No.: 33,500

G&C 30794.94-US-WO